EE283 Laboratory Exercise # 1

Basic Circuit Concepts

Objectives:

1. To become familiar with the DC Power Supply unit, analog and digital multi-meters, fixed and variable resistors, and the use of solderless breadboards.
2. To verify Ohm's law.
3. To understand series and parallel connection of resistors.

Procedure:

1. Meters and Power Supply

Familiarize yourself with the analog multi-meter, or Volt-Ohm Meter (VOM), digital multi-meter (DMM), and the DC power supply unit. Basically, a multi-meter is a combination of a voltmeter (to measure voltages), an ammeter (to measure current), and ohmmeter (to measure resistances). When used to measure voltage of an element, the meter should be connected ACROSS the element. When used to measure current through an element, it should be connected IN SERIES with the element. When a meter is used as an Ohmmeter to measure the resistance of an element, the meter is connected ACROSS the element with the precaution that the element should not be connected to any power source.

The power supply has three independent supplies in one unit. One of those supplies a fixed 5 Volts; we will use that for digital circuitry later. The others can be set to be a Voltage source (normal mode) or a current source. Two knobs control Voltage and the current limit. If the current limit is too low, or the current drawn is too high, say, due to a short circuit, a red LED will indicate that, and the Voltage will be less than the set value. Small digital meters on the power supply can be used to indicate either Voltage or Current. They are not as accurate as measurements made with dedicated meters, so use your meter, not the power supply readings, for measured supply Voltages in laboratory exercises.

To set a current limit, first set the Voltage turned to a low value, maybe 2 Volts or so. Then, deliberately short out the power supply by connecting the positive terminal (Red) directly to the negative terminal (Black). The Voltage (seen using the supply meter) should drop to zero and the red current limit LED should come on. Set the meter to current. Adjust the current limit knob for 50 mA (.05A) or whatever other value is desired. Then remove the short and adjust Voltage. The supply will now limit the supplied current to the set limit.

2. Fixed Resistors

Choose five resistors of different values from those provided (most should be in the range from 1.0 kΩ to 10 kΩ). Write the color code for each resistor, determine the resistance using the code, measure the resistance using the analog meter (VOM), and also measure the resistance using the laboratory digital meter (DMM). Enter the readings in a table. Here and later, use appropriate numbers of significant digits. The code value, or nominal resistance, should have two digits. Include the tolerance. Measured values should be as many digits that you can accurately and consistently measure. (Notice what happens on the DMM resistance measured value if you pinch a resistor tightly with your fingers for a while.)

3. Variable Resistor

Use a variable resistor (10K Ohms) and determine the range over which the resistance can be varied and the resistance value for two variable positions using both an analog and a digital meter. Enter the readings in a table. Use estimated degrees of rotation clockwise for mechanical position (Don't use max CW or max CCW. Make one about half way.). (You should solder hookup wire leads to the three terminals of your variable resistors (often called potentiometers, or "pots") when you can do so. I suggest black (left), some other color, perhaps green (center), and red (right) for the three terminals.) See Figure 1.1.

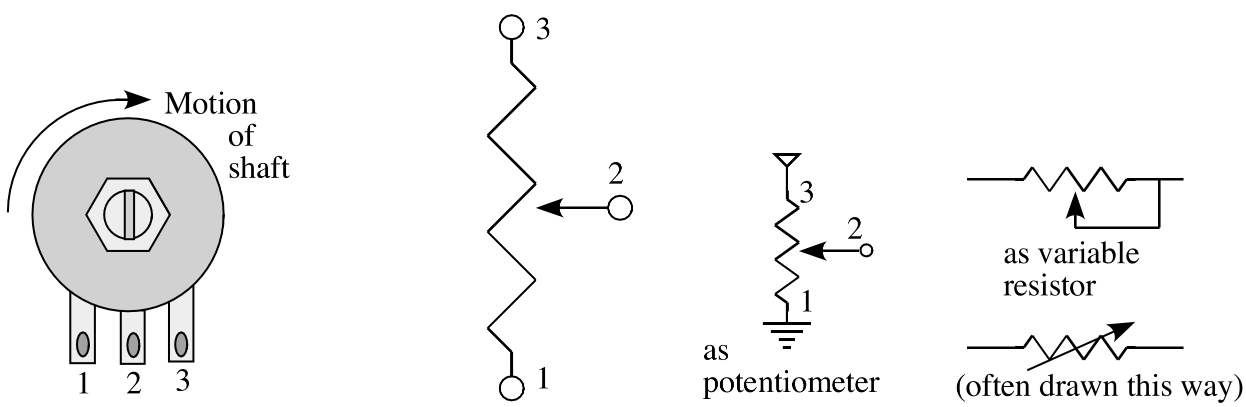

Figure 1.1(a) Potentiometer   Figure 1.1(b) symbol   Figure 1.1(c) circuit use

4. Ohm's Law Verification

Theory: Ohm's Law states that the current I through a resistor R is proportional the voltage V across it. The constant of proportionality is called the resistance. Mathematically,

$$V = IR \quad \text{OR more generally} \quad v(t) = R\, i(t) \tag{1.1}$$

Figure 1.2 shows the circuit schematic that can be used to show this relationship including the actual connections made to the meters. R can either be a fixed or a variable resistor.

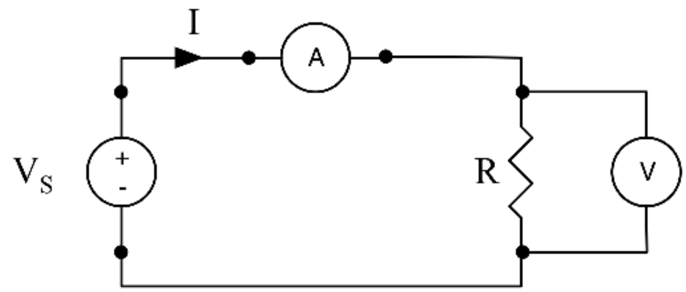

Figure 1.2. Circuit schematic to verify Ohm's law

Ask your instructor or a student assistant to check the connection. Supply a suitable initial DC Voltage, perhaps 4 Volts, using the DC Power Supply. Measure the current using, preferably, a DMM and the Voltage using, preferably, a VOM. **Repeat this for four values** of the supply Voltage. Calculate the resistance value in each case as the ratio of voltage to current and enter the readings and results in a table. Switch off the supply, remove the resistor, and measure its value (using preferably, a DMM). Record the measurement

Note: If the ammeter is connected incorrectly (shorting the voltage source) it will blow the internal fuse. Have the instructor or an assistant verify that your circuit is connected correctly. Once verified, you may turn on the power to your project board, and continue.

5. Series Connection of Resistors

Theory: When resistors are connected in series as shown in Figure 1.3, the equivalent resistance R is given as:

$$R = \sum_{i=1}^{N} R_i \qquad (1.2)$$

where R_i is the resistance of the i^{th} resistor.

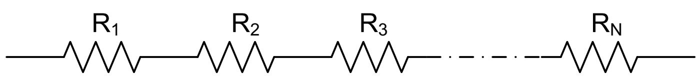

Figure 1.3. Series connection of resistors

Select four resistors; measure each resistance (if not measured already). Connect them in series and measure the equivalent resistance R using VOM. Calculate the equivalent value R using equation (1.2)

Compare the measured and calculated values of the resultant resistance R.

Note: Use your solderless breadboard to construct the circuit. Think carefully about the connections between the holes on the same and different rows. It is too easy to insert a resistor such that it simply connects both ends together, creating a zero Ohm resistance. See Figure 1.4

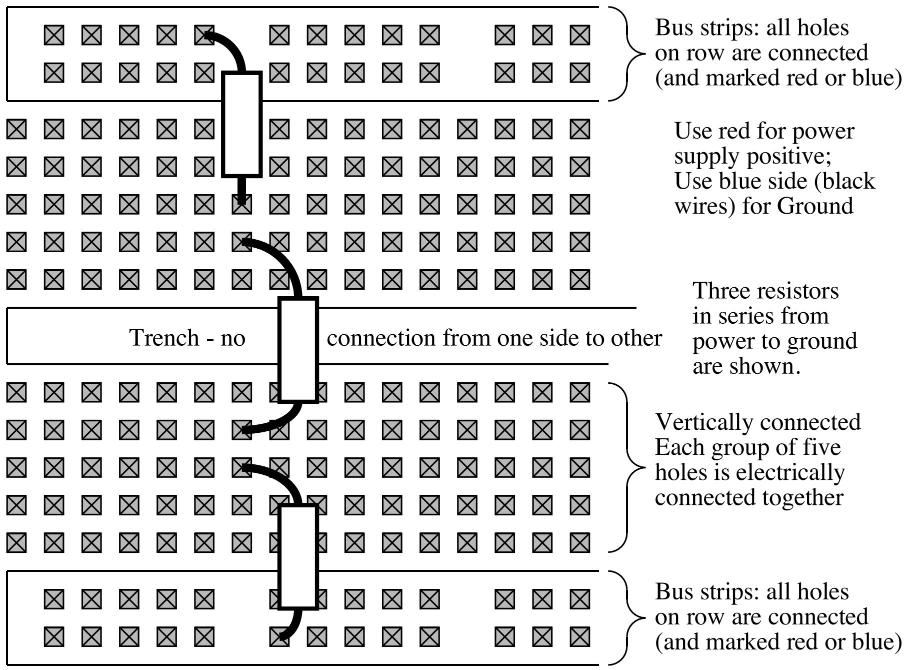

Figure 1.4 Breadboard Connections

6. Parallel Connection of Resistors

Theory: When resistors are connected in parallel as shown in Figure 1.5, the equivalent resistance is given as:

$$\frac{1}{R} = \sum_{i=1}^{N} \frac{1}{R_i} \tag{1.3}$$

where R_i is the resistance of the i^{th} resistor.

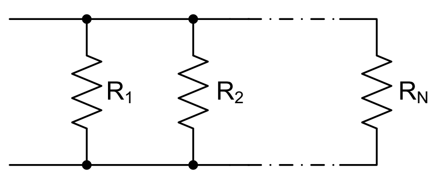

Figure 1.5. Parallel connection of resistors

Select four resistors. Measure each resistance (if not measured already). Connect them in parallel, and measure the equivalent resistance R. Calculate the equivalent value R using equation (1.3)

Compare the measured and calculated values of the resultant resistance R.

Note: Use your solderless breadboard to construct this circuit. Think about how to measure current. The meter must be placed in <u>series</u> with each resistor in turn. If you place an ammeter across the resistor, you short it out. You get the equivalent of zero Ohms, which can blow out the fuse in the Ammeter. Before doing this part of the exercise, set a current limit on your power supply at about double the expected current, and no more than 50 mA.

7. Series/Parallel Connection of Resistors

Select a few resistors; measure each resistance (if not measured already). Connect the resistors in a series/parallel combination assigned by the instructor and measure the equivalent value. Calculate the equivalent value and compare that to the measured value.

8. Report

Turn in a report on the supplied form at the end of the laboratory period. Keep a copy of the values recorded for the "Ohm's Law" verification. Each student is to use Excel to develop a properly annotated graph showing these results. These graphs, with the student's name, section, and lab station, are to be turned in at the beginning of the following laboratory session. See the Engineering Laboratory Reports Manual on doing proper graphs.

(See:< http://www.jbgilmer.com/LabManual/LabReportsManualAppB.pdf>)